burn 1 grid the poorly represented *A. chrysophilus* disappeared. *C. hirta* numbers remained about constant and *P. natalensis* and *L. griselda* declined noticeably.

Sex ratios

Both sexes of *P. natalensis* reacted alike to the various burning treatments. Swanepoel (1981) also reported no significant post-burn changes in sex-ratio of *P. natalensis.* The post-burn sex ratio of *L. griselda,* however, changed noticeably with an increase in number of females caught. The findings of Swanepoel (1981) too showed relatively more *L. griselda* females caught after the fire.

Reproduction

Christian (1977) found that the effects of fire did not drastically alter the intensity or timing of breeding of deserticolous *Gerbillus paeba* or *Desmodillus auricularis.* Begg et al. (1981) established that fire affected reproduction and recruitment in all four species in his study area which ranged from closed forest to perennial grasslands. In the present study the difference in breeding to non-breeding ratios of *P. natalensis* in November 1982 on the various burning treatment areas suggested an influence of fire on reproduction; more adults came into reproductive condition on the clean-burn grids.

The reproductive trigger may be low density but Delany (1972) infers that the onset and termination of breeding could be correlated with biochemical and quantitative changes in diet.

Range distance

Christian (1977) has reported that if any critical resources have been destroyed by fire it is likely that survivors on the burnt area would range over greater distances in search of food and cover. The two species studied, *G. paeba* and *D. auricularis,* both had a greater range on the burnt area than on the unburnt area. Kern (1977) also found a slight increase in the home range of *T. leucogaster* on burnt areas.

The range distances on the clean-burn treatments of *P. natalensis* increased after the burns while those on the no- and patchy-burn areas decreased. Though these trends are statistically not significant they do suggest that mobility is probably influenced by an interaction of the effects of fire (sub-optimal habitat, food scarcity) and population densities.

Survival rate

Christian (1977) found the survival rate higher, though not significantly so, on the burnt area whereas in the present study the survival of *P. natalensis, A. chrysophilus* and *L. griselda* was higher on the no-burn area. *P. natalensis* showed more resilience in the clean-burn 2 area than the patchy-burn area. Perhaps the intense post-burn disruption and the onset of the drought resulted in the heavy mortality in this area.

The present study showed that the small mammal community is able to cope with the fire itself as numerous aspects (sex ratios, species composition, age structure, diversity) were relatively unaffected. The incidence of fire in the home range of a small mammal is a brief event and only fatal if the animal is engulfed by the flames or asphyxiated by the fumes. Mortality, as a direct result of fire, seems to occur seldomly. The major impact of fire on the small mammal community which leads to marked declines in abundance stems from the sudden and extreme modification of the habitat whereby food supply and cover are removed.

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Zusammenfassung

Der Einfluß von Bränden auf die Kleinsäuger im Hluhluwe-Wildreservat

Untersucht wurde der Einfluß von Bränden auf die Kleinsäuger. Dazu wurden vom Juli 1982–Dezember 1983 die Kleinsäugerbestände von vier Probeflächen, die vollständig, teilweise oder gar nicht abgebrannt wurden, durch Markierungsfang verfolgt. Auf der nicht und der nur teilweise abgebrannten Fläche stieg die Anzahl der Nager unmittelbar nach dem Brand an. Bei direkter Beobachtung wurden keine vor dem Brand flüchtenden Kleinsäuger festgestellt. Die Artenzusammensetzung und Diversitätsindices blieben nach Bränden relativ unbeeinflußt. Bei *Praomys natalensis* waren die verschiedenen Altersgruppen nicht signifikant verschieden vom Feuer betroffen. Eine Zunahme der Weibchen, die bei *Lemniscomys griselda* nach dem Brand auftrat, war nicht signifikant. Auf völlig abgebrannten Flächen war der Anteil sich fortpflanzender *P. natalensis* erhöht. Die mittlere Aktionsraumgröße nahm bei *P. natalensis* mit zunehmender Dichte ab. Die Überlebensrate der Nager schien auf den nicht abgebrannten Flächen größer zu sein. Eine Dürre in den Jahren 1982/83 führte zu einer allgemeinen Abnahme aller Kleinsäuger des Beobachtungsgebietes in dieser Zeit.

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Responses of Apennine chamois to human disturbance

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Abstract

The study measured the effects of human disturbance on the behaviour of different age groups of Apennine chamois *Rupicapra pyrenaica ornata* in three areas with different levels of human presence in the upper Val di Rose, Abruzzo National Park, Italy, in July 1986.

There was no consistent difference in flight distance between the sexes or between grazing and resting animals, in response to standardised experimental approaches, but yearling and sub-adult chamois had significantly shorter flight distances than had young adults. Females with kids had significantly longer flight distances than those without, although the difference was confined to resting animals. Flight distances were least in the area with most visitors and were longest in the most remote area and there was evidence of habituation with repeated exposure to people.

Introduction

The population of chamois *Rupicapra pyrenaica ornata* in the Italian Apennine Mountains numbers fewer than 400 animals, confined to a small area in the Abruzzo National Park, and is described as vulnerable by I.U.C.N. The animals are subject to considerable human disturbance; Cederna and Lovari (1985) showed that the many visitors to the Park (2039 in one study area; 30 days' observation) caused disruption to grazing by forcing the animals to retreat to rock faces. Grazing was completely prevented during the mid-morning peak of tourist activity.

Lovari and Rosto (1985) found that even in the apparent absence of human disturbance, younger, subordinate female chamois grazed at a significantly lower rate and were significantly more vigilant than older, dominant females. Intra-group social rank factors were likely to be involved but it is also possible that human presence might affect the feeding of younger chamois more than that of older ones.

The aims of the present study were: 1. to measure the effects of human disturbance on the behaviour of Apennine chamois of different age and sex, in relation to their previous behaviour (grazing or resting); 2. to compare the responses of animals in different areas of the Abruzzo Park with different amounts of human disturbance; and 3. to find whether chamois would habituate to the continual presence of people.

Study area

The main study areas were in the upper part of the Val di Rose in the Abruzzo National Park (Fig. 1), an area of limestone ridges and alpine meadows at 1850–1942 m altitude. Three areas were used: Passo Cavuto, which was visited very frequently by walkers in summer; Boccanera, which was not used by walkers but where the animals were accustomed to the frequent presence of observers; and Sterpi d'Alto, where the animals were approached less frequently. A few observations were also made on Mt. Amaro, 4 km to the NW, where the animals were less accustomed to people. The study was carried out during July, 1986.

Each of the main study areas supported a largely separate flock of up to 30 chamois, some of which had been ear-tagged for individual recognition in earlier studies.

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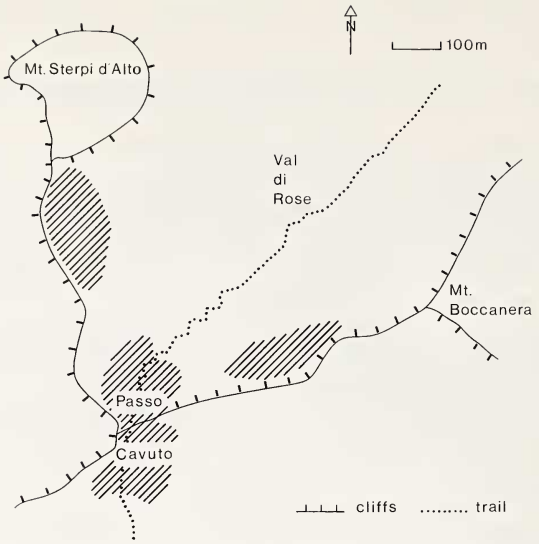

Fig. 1. The main study areas (shaded) in the upper Val di Rose, Abruzzo National Park, L'Aquila, Italy

Material and methods

Animals were allocated to age classes, using the length of their horns in relation to ear length (Lovari 1985): yearlings had horns around or a little less than the length of their ears; sub-adults (2–3 years old) had horns ¼ – ⅓ longer than the ears; young adults (4–5 years old) had horns 1½ times ear length while adults (over 5 years of age) had horns at least twice the length of the ears. In animals at least two years old, males could be distinguished by their thicker, more strongly curved horns and their penile hair tuft. Yearling males and females were not distinguished.

Some naturally-occurring disturbance of chamois by visitors was observed at close range but such incidents were highly variable in the number of people involved, their direction and speed of approach, whether they were noisy or quiet, etc., so the main study used standardised approaches by the observer. After an initial acclimatisation period of at least 10 min an animal with no others between it and the observer was selected and its sex, age class and activity (grazing or resting) were noted. It was then approached across the slope at a slow walk (0.25 m/s), avoiding any noise or sudden movements. The distance between the animal and the observer was measured with a range-finder whenever there was a change in the chamois' behaviour and the approach was suspended immediately the animal began to move away. The observer then retreated before starting to approach a new animal.

As far as possible, only one approach was made to each animal in a flock on each day, but animals without ear tags were undoubtedly approached on different days, leading to some non-independence in the data and consequent need for caution in the interpretation of statistical tests. Where repeat approaches were carried out on ear-tagged animals, a mean value for each has been used.

Results

Behavioural responses to human approach

In almost all of the 225 approaches made in the main study areas the animals showed the same sequence of behaviour; grazing animals stopped feeding, oriented their heads towards the observer (noted as the alert distance) and moved away, usually with their tails raised (noted as the flight distance); similarly, resting animals oriented and rose to their feet before moving off. Only 3 % omitted orientation of the head before moving. Many (45 %) of the 31 resting animals which were ruminating steadily before being approached continued to do so until they moved off and a further 29 % even continued to ruminate as they moved. Alarm snorts were given in only 4.5 % of approaches.

The changes in the animals' behaviour during approaches tended all to occur within a few seconds, at the same distance from the observer; in only 23 % of approaches did the animal stop activity and orient to the observer at a distance greater than the eventual flight distance. The proportion doing so was, however, significantly higher in resting than in grazing animals and was slightly but not significantly greater in females accompanied by kids than in other adults females (Table 1). In such animals the mean difference between

Table 1. **Percentage of animals with alert distance greater than flight distance**

	Grazing			Resting		
	N	Alert	%	N	Alert	%
			Without Kids			
Pass	86	7	8.1	45	18	40.0
Boccanera	23	1	4.3	5	5	100.0
Sterpi d'Alto	34	8	23.5	9	3	33.3
Total	143	16	**11.2**	59	26	**44.1**
	$\chi^2 = 27.42$; $p < 0.001$					
			With Kids			
Pass	3	1		3	1	
Boccanera	6	1		5	4	
Sterpi d'Alto	3	1		3	1	
Total	12	3	**25.0**	11	6	**54.5**
	$\chi^2 = 2.10$; NS					

Overall, 22.7 % with alert distance greater than flight distance.

the alert and flight distances was 1.53 ± 0.15 m (grazing), 2.02 ± 0.25 m (resting) and 3.11 ± 0.56 m in females with kids. (There were no statistically significant differences, however, between these distances.)

Since the majority of animals became alert and then moved away without further approach by the observer, flight distances alone were used in most of the following analyses.

Flight distances in relation to previous activity

This could be compared in nine categories of animal (excluding females with kids); in adult females on Sterpi d'Alto the flight distance was significantly higher in grazing than in resting animals but there was no significant or consistent difference in any of the other groups (Table 2). Marked animals approached both while grazing and while resting also showed no consistent difference in flight distance. Alarm snorts, although uncommon, occurred in 10.2 % of 59 approaches to resting animals but in only 2.1 % of 143 to grazing ones ($\chi^2 = 6.39$; $p < 0.01$). They occurred in a quarter of the eight tests on Mt. Amaro.

Among females accompanied by kids, resting animals had significantly higher flight distances than had grazing ones in the Pass and Boccanera areas (Fig. 2). On Sterpi d'Alto, grazing females with kids had flight distances as long as those of resting ones.

Flight distance in relation to the sex of the animal

This could be compared in only five categories of sub-adult, since the sex of yearlings was not determined and adult males were uncommon in the study area. There was no consistent tendency for one sex to have a greater flight distance (Table 3). Subsequent sections will therefore combine grazing and resting animals of both sexes (excluding females accompanied by kids).

Table 2. **Flight distance in grazing and resting animals**

Age/Sex	Area	Grazing N	Grazing $\bar{x}$	Grazing SE	Resting N	Resting $\bar{x}$	Resting SE
Yearlings	Pass	18	11.8	0.6	16	10.0	0.7
2–3 yr ♂♂	Pass	20	10.6	0.5	15	11.8	1.3
2–3 yr ♂♂	Sterpi	3	17.3	2.0	2	14.0	1.0
2–3 yr ♀♀	Pass	9	9.7	0.6	5	11.8	0.9
2–3 yr ♀♀	Boccanera	5	13.0	1.9	2	14.0	4.0
2–3 yr ♀♀	Sterpi	2	13.3	2.7	3	14.3	0.9
4–5 yr ♀♀	Pass	17	12.8	0.5	5	11.0	0.7
5+ yr ♀♀	Pass	20	12.3	0.5	3	10.5	0.8
5+ yr ♀♀	Sterpi	14	17.9	1.2	3	13.7	0.9*

* t = 2.86; p = 0.017; no other significant differences.

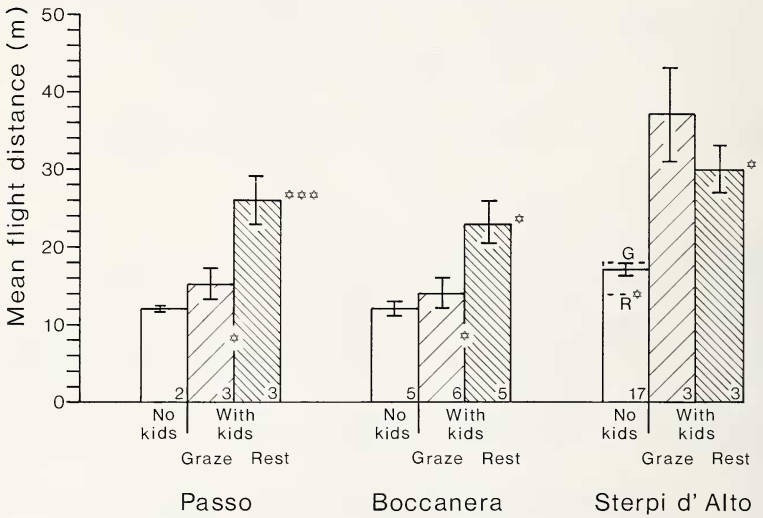

Fig. 2. Flight distances in adult females with and without kids. Asterisks above the columns indicate significant differences from females without kids (* – $p < 0.05$; *** – $p < 0.001$, t tests). Asterisks within columns indicate significant differences between grazing and resting animals ($p < 0.05$, t tests)

Table 3. **Flight distance in male and female sub-adults**

Area	Activity	Male N	Male $\bar{x}$	Male SE	Female N	Female $\bar{x}$	Female SE
Pass	grazing	20	10.6	0.5	9	9.7	0.6
Pass	resting	15	11.8	1.3	5	11.8	0.9
Boccanera	grazing	2	13.0	1.0	5	13.0	1.9
Sterpi d'Alto	grazing	3	17.3	2.0	2	13.3	2.7
Sterpi d'Alto	resting	2	14.0	1.0	3	14.3	0.9

No significant differences.

Flight distance in different age classes

Contrary to expectation, young chamois were not more sensitive to disturbance than were older ones – yearlings and sub-adults had slightly but significantly shorter flight distances than had young adults (Fig. 3). Analysis of variance, however, showed no significant variation in flight distance over the four age groups taken together.

Fig. 3. Flight distance in relation to age. Grazing and resting animals of both sexes have been combined, omitting only those with kids. Young adults vs. sub-adults and yearlings, $p < 0.05$ (t tests)

Resting females with kids had longer flight distances than females without kids in all of the three main study areas (Fig. 2). Three ear-tagged females, approached while resting away from their kids, all had shorter flight distances than when resting with their kids.

Flight distance in different areas

In all age groups there was significant variation in mean flight distance between the three main study areas (ANOVA; $p < 0.01$), with the shortest distances in the heavily visited Pass area and the longest in Sterpi d'Alto, where the animals were visited least (Fig. 4). The moderately-studied Boccanera area was intermediate, but young adults there had significantly longer flight distances than those in the Pass area. One marked adult female seen in two areas had a longer flight distance when she was on Sterpi d'Alto than when she was in the Pass. The small number of observations made on Mt. Amaro suggested that flight distances there were about twice those at the Pass (Fig. 4).

Flight distance with repeated approach

When the approaches made to a given sex and age category in each study area were divided into their earlier and later halves, all seven categories with sufficient data showed a shorter flight distance in the second half of the study compared to the first, with significant differences found among yearlings and subadult males (Table 4). Overall, the mean reduction in flight distance was 1.7 m. Six marked animals approached more than once over the study period showed no consistent change in flight distance, but successive approaches were usually at intervals of several days. However, in four animals approached two or three times in quick succession, only two showed a reduction in flight distance while one stayed the same and one showed an increase.

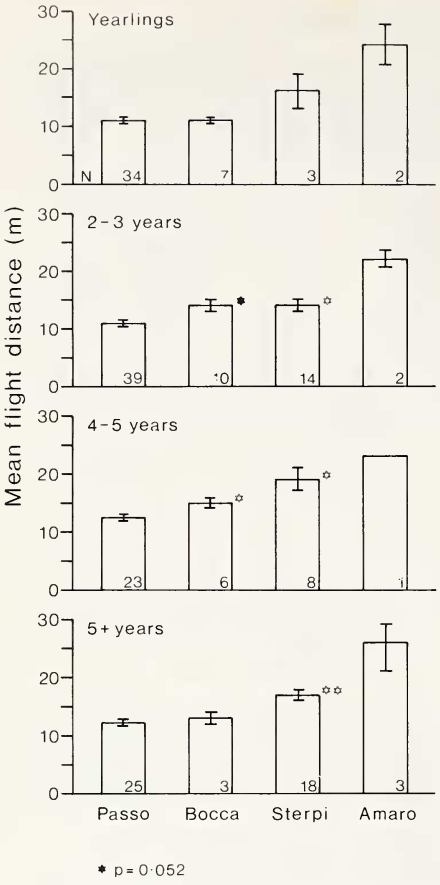

Fig. 4. Flight distance in different study areas; categories of animal as in Fig. 3. Single asterisk indicates significant difference from Pass ($p < 0.05$; t tests); double asterisk indicates significant difference from Pass and Boccanera ($p < 0.01$, t tests)

Discussion

Yearling and sub-adult chamois, although found by Lovari and Rosto (1985) to be more vigilant than older ones, did not become alert and flee from a quietly-approaching person at greater distances than did older animals; indeed they allowed significantly closer approach than did young adults. This supports Lovari and Rosto's (1985) suggestion that the vigilance of younger animals may be mainly social, with attention directed at other chamois. It is also possible that the animals were looking out for other potential predators such as canids and were not concerned about people. There may also be a higher level of curiosity in younger animals, counteracting fear and leading to their staying longer while being approached.

Resting animals might be expected to have shorter flight distances than grazing ones, which can move away easily, while the resting ones have first to rise to their feet, which might require a higher threshold of fear to be exceeded. However, most chamois showed no difference in flight distance with previous activity, with only adult females on Sterpi d'Alto having significantly shorter flight distances while resting. The opposite was true for females accompanied by kids in the Pass and Boccanera areas. In these, the longer flight distances of resting animals may be related to a greater vulnerability of sitting animals to a sudden rush by predator. This, however, explains only the animals' rising to their feet as a "precautionary" measure, not

Table 4. **Change in flight distance with repeated approach**

Age	Sex	Activity	Area	First half of approaches			Second half of approaches			t	p
				N	$\bar{x}$	SE	N	$\bar{x}$	SE		
1		G	Pass	10	**12.2**	0.9	9	**11.3**	0.6		
1		R	Pass	8	**11.3**	1.0	8	**8.6**	0.6	2.29	.045
2–3	M	G	Pass	10	**11.4**	0.7	10	**9.9**	0.8		
2–3	M	R	Pass	8	**14.1**	1.8	7	**9.1**	1.2	2.30	.042
4–5	F	G	Pass	8	**13.3**	1.0	8	**12.4**	0.3		
5+	F	G	Pass	9	**12.7**	0.9	8	**12.2**	0.9		
5+	F	G	Sterpi	7	**18.0**	1.8	6	**17.5**	1.9		

Difference in the same direction in all 7 sets; $p < 0.05$, Sign Test.